

Account of some New Experiments on the Sensibility of the Skin, by Dr WEBER, Professor of Anatomy at Leipzig. By ALLEN THOMSON, M. D.

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IT is a fact well known to physiologists, that there is a considerable difficulty in pointing out with certainty, when unaided by sight, any spot on the skin that has been touched, and in distinguishing how much of the common feelings of touch is due to the sensibility of the skin, and how much is derived from the muscular sensation produced by the motion of our limbs. It is also well ascertained that some parts of the skin are better adapted than others, either from their original structure, or in consequence of their being more exercised, to convey to the mind an exact impression of the physical qualities of the bodies with which they are brought in contact. It must be allowed, however, that our knowledge respecting this part of the physiology of the sense of touch is by no means definite.

Professor Weber of Leipzig has lately performed a very simple and ingenious set of experiments which illustrate the subject of the sense of touch, and furnish us with a mode of measuring with considerable accuracy, the relative acuteness of this sense in different parts of the skin of the same or of different individuals.

These experiments consist in placing the two points of a pair of compasses at different distances from one another, and in various directions, upon different parts of the skin of an individual who is not permitted to see the bodies touching him.*

* The sharp points of the common compasses may be blunted with a little sealing-wax, which will have the effect also of taking away the cold feeling of the metal.

Professor Weber thus found, that, according to the distance of the two points from one another, we may have the feeling either of one only or of two tangent points, and that the distance at which we become sensible of the double impression is in the inverse proportion to the acuteness of the sense of touch in the skin ; or, in other words, that we recognize a double impression made on very sensible parts of the skin, although the points are situated very near one another, while in those parts of the skin in which the sense of touch is obtuse, the points may be removed to a considerable distance from one another, and yet convey to us the feeling of only one impression.

In August 1831, Professor Weber was so kind as to show me some of the more striking of his experiments, and at the same time presented me with an account of them originally published in detached parts as "Annotationes" to some of the inaugural dissertations of the Leipzig University. He had also printed these annotations in a separate form, but I am not aware whether they have ever been published. To the best of my knowledge no notice of these experiments has as yet appeared in this country, which induces me to believe that a short account of them will be acceptable to the readers of the *Edin. Med. and Surg. Journal*.

Professor Weber has embodied the principal results of his experiments on the varieties in the acuteness of the sense of touch of different parts of the skin in eight propositions, of which the following is an abstract.

Prop. 1. The different parts of the skin or organ of touch do not possess an equal power of distinguishing two bodies by which they are touched at the same time. The distance of the two touching bodies being known, the degree of this power may be measured ; for it is ascertained that if the organ of touch does not perceive the contact of two bodies when they are near one another, it becomes sensible to the impressions of both when the distance between them is increased.

If the touching points are sufficiently distant, we not only distinguish the impressions of both, but also the direction, longitudinal or transverse in relation to the body, in which they are applied to the skin. When they are brought nearer to one another they first give the sensation of the contact of a long body, but when brought still closer together they appear as a single point upon the skin.

The ends of the fingers and the tip of the tongue have the power of distinguishing the distance of two points nearly equal, and in a much greater degree than any other part of the body. At two-fifths of a Paris line we are capable of distinguishing the longitudinal from the transverse position of the points on the tip of the tongue. At half a line two impressions are felt,

more especially when the points are made to touch at the same time the upper and lower margins of the tongue, or the dorsal and palmar sides of the fingers; but in most other parts of the body this is different; for

Prop. 2. In many parts of our bodies we perceive the distance and situation of two points touching us at the same time more distinctly when they are placed parallel to the transverse than to the longitudinal direction of the body.

This may easily be tried in the middle of the arm or forearm: here the two points may be distinguished at a distance of two inches when placed in a direction across the arm, but they appear as one at this distance, or even (in some persons) at three inches when placed longitudinally.

Under this proposition Professor Weber has placed a very long table, which may be considered as a detailed register of his experiments, and in which are exhibited the distances at which he was sensible of a single or double impression from the contact of the two points with different parts of his skin. It is difficult on a cursory view of that table to follow the general results, and on this account I have preferred giving only a shorter and more illustrative one which follows it, in which the parts of the skin are arranged according to the acuteness of their sense of touch, as measured by the smallest distance at which the horizontal or transverse position of the two points and a space between them could be distinguished.

	Paris lines.
Tip of the tongue,	$\frac{1}{8}$
Palmar surface of the 3d phalanx of the fingers,	1
2d	2
Red surface of the lips,	3
Point of the nose,	4
Dorsal surface of the 3d phalanx of the fingers,	5
Palmar surface of the heads of the metacarpal bones,	6
Dorsum of the tongue, 1 inch from the tip,	7
White surface of the lips,	8
Margin of the tongue 1 inch from the tip,	9
Metacarpal part of the thumb,	10
Point of the great toe,	11
Skin covering the buccinator,	12
Dorsal surface of the 2d phalanx of the finger,	13
Palmar surface of the hand,	14
External surface of the eye-lid,	15
Mucous membrane on the middle of the hard palate,	16
Anterior part of the zygomatic bone,	17
Plantar surface of the metatarsal bone of the great toe,	18
Dorsal surface of the 1st phalanx of the fingers,	19

	Paris lines.
Dorsal surface of the heads of the metacarpal bones,	8
Mucous membrane of the lips near the gums,	9
Posterior part of the zygomatic bone,	} 10
Inferior part of the forehead,	
Posterior part of the heel,	} 12
Inferior part of the hairy occiput,	
Back of the hand,	14
Neck under the lower jaw,	} 15
Vertex of the head,	
Patella and thigh near it,	16
Sacrum,	} 18
Shoulder and arm near it,	
Gluteal region and thigh near it,	} 18
Superior and inferior part of the fore-arm,	
Leg near the knee and foot,	} 20
Dorsum of the foot near the toes,	
Sternum,	20
Spine of the back at the fifth superior vertebra,	} 24
Neck near the occiput,	
Loins and bottom of the thorax,	} 30
Middle of the back of the neck,	
Middle of the back,	} 30
Middle of the arm, except where the muscles swell most,	
thigh,	} 36 to 42
On these swellings of the muscles on the extremities, as	
also over the sacro lumbales, from	36 to 42

Prop. 3. In those parts of our body in which the impressions of both points are clearly distinguished although not distant, the space between these points appears to be greater than in other parts possessing a less sensible touch.

The experiments illustrative of this are very striking. They may be best performed by drawing both the points of the compasses gently along the skin, from a sensible to a less sensible part, or *vice versa*; as from the hand along the fingers, from the cheeks or ear across the lips, and towards the nose; from the jaw to the chin, from the occiput to the sacrum, with a point on each side of the median line, and from the chin to the pubis, in the same manner. In passing over the more acutely sensible parts, the points of the compasses seem to open or to recede from one another, and the reverse takes place in those regions in which the sensibility is obtuse.

Prop. 4. If the points are placed on two contiguous parts which may be moved voluntarily and independently of one another, the double impression is much more clearly perceived,

and the points appear more remote from one another, than if at the same distance, they were brought in contact with one entire part. This is easily shown on the lips, fingers, and eye-lids.

Prop. 5. We distinguish the two points more clearly, if they are brought into contact with two surfaces having a different structure and use, than when they are applied to one and the same surface.

This rule also holds in respect to surfaces possessing different degrees of sensibility; for in this case also, the points are more clearly distinguished when they touch two contiguous surfaces of different powers, than when they are both placed on the most sensible of them. This may be seen on the lips, by placing one point on the internal, and another on the external surface, in which position the points are distinguished at a smaller distance than in any other, although the surface of the lips directed towards the gums has a much less acute sense of touch than the red part. The same is the case with the white and red external surface of the lips.

To the same general rule may be referred another fact, viz. that a smaller distance of the points is perceptible when they touch at once the palmar and the dorsal surfaces of the fingers, than when they are both applied to one of these surfaces; and it may also be stated, under this head, that this power of distinguishing the points is generally greater when they are applied at equal distances on each side of a median line of the body.

Prop. 6. If we examine attentively the degree of acuteness of the touch in each part of the body, we shall find that this varies not only in the larger parts, but that there are also small spaces, in some of which the sense is more acute, in others in the immediate neighbourhood more obtuse. These points, however, do not vary to a great extent in the degree of their acuteness, nor has Professor Weber discovered any fixed order according to which they are disposed.

This observation would seem to show that the nervous fibriles are not quite equally distributed throughout the skin.*

Prop. 7. If we are touched with greater force by one of the points than by the other, the impressions of both are distinguished less easily; for the stronger obscures the weaker.

Prop. 8. We distinguish two separate impressions more easily when they are not made exactly at the same time; and on this account, in performing all the experiments previously referred to, it is necessary to pay great attention in order to make the contact of both points synchronous.

* The presence of these slight variations appears to be indicated remarkably in some parts of my skin, by a very curious feeling of irregularity, which occurs when one or two points are drawn along these parts.

After announcing these general propositions, Professor Weber proceeds to describe some varieties in the sensations communicated by the contact of the two points in particular regions of the body.

Touch in the Extremities.—The middle of the arm, thigh, fore-arm, and leg, or a place near it, at which the greatest quantity of muscles is collected, has the bluntest sense of touch, the fore-arm is a little more sensible than the arm, the leg than the thigh, and the fore-arm is on the whole more sensible than the leg. The convex part of the joints as the skin over the patella, olecranon, and acromion are more sensible than that in the popliteal space, the bend of the arm and the axilla. The internal surface of the arm, and the posterior surface of the leg, do not differ much respectively from the external nor anterior. The arm and leg are far excelled by the hand and foot, and the hand is greatly superior to the foot. In the hand, touch is much more acute on the palmar, than on the dorsal surface. The skin over the heads of the metacarpal bones is more sensible than that in the middle of the palm; and the sensibility gradually increases from thence towards the points of the fingers. The heel is more sensible than the middle of the sole of the foot. The dorsum of the hand and foot are surpassed by the lower ends of the fore-arm and leg. In general the distal end of the arm and leg is more sensible than that towards the trunk, yet the skin over the deltoid muscle surpasses that towards the elbow.

In the extremities the transverse is always much more easily perceived than the longitudinal position of the touching points.

On the Head.—The hairy scalp is the least sensible part of the skin of the head; it is more sensible, however, than that of the neck. The skin near the forehead and temples is more sensible than that on the vertex. The sides of the jaws come next, and the parts of the face are more and more sensible, as they are nearer the median line, the point of the nose and the red part of the lips. The inner sides of the lips are less sensible the farther they are from the margins. The gums are susceptible of considerable pain, but possess very little power of distinguishing the distance of the two points. It would appear that we can sometimes ascertain the distance and direction of the points by means of the teeth or their pulps. The most sensible part of the point of the tongue occupies only a small space—four or six square lines. The touch of the tongue becomes less acute on all sides as we recede from this. The soft palate has a more acute sense of touch than the hard palate.

On the Trunk of the Body.—The sense of touch on the surface of the trunk of the body is less acute than that of the head and extremities; and there is no part of the trunk pos-

sessed of the same acuteness as the tongue, lips, fingers, nose or hand. The mammæ even have not an acute sense of touch. From this, as well as several other observations, the important deduction may be made, that the acuteness of the sense of touch is very little connected with or in proportion to the susceptibility of the skin to be affected with pain or titillation, and that tenderness of the skin by no means indicates acute sensibility, or acuteness of the sense of touch.

One of the most important differences between the sense of touch in the trunk and that in the extremities consists in this, that on many parts of the trunk the horizontal or transverse position of the points is not more easily recognized than the perpendicular or longitudinal.

In a considerable series of experiments which Professor Weber made in illustration of the relative acuteness of the sense of touch in different parts of the trunk, he chose three horizontal lines encircling the body in the regions of the neck, thorax, and abdomen, and four vertical lines, passing from the head downwards to the inferior extremities, and measured the power of touch as before, by placing the two points at different distances and in various directions on these lines.

In placing the two points at a distance of about two inches, in a horizontal position, on the line surrounding the thorax, from the ensiform cartilage, a little below each mamma, he found that there are four places at which the distance of the two points is most obvious. These places are in the middle before and behind, and on the two sides. We perceive the two points most distinctly when they are placed equidistant on each side of the median line; the clearness of the double impression diminishes as soon as they are moved to one or other side. Nearly the same, though with less distinctness, is the case in the middle of the two sides.

On applying the two points in a vertical direction across the horizontal line surrounding the thorax, there are four places in which the double impression is less clearly perceived than in others; or the sensibility appears most obtuse in the same region in which the horizontal application of the points is most clearly perceived; and *vice versa*. This inverse ratio does not, however, hold in all the intermediate regions.*

In the second horizontal line surrounding the abdomen about an inch above the umbilicus, the longitudinal and transverse

* It must be remarked, that, in Professor Weber's account of his experiments, there is an apparent contradiction in respect to this; for at one place he says there are four places in which the vertical position is least clear,—two behind and before, and two on the side; and at another he says, that it is clearest of all on the sides. I have found the vertical position of the points more clearly distinguishable on the line passing from the axilla to the ileum, than either before or behind it.

application of the two points give nearly the same results as in the thorax. But, in the third line surrounding the neck, Professor Weber states, that the results were so inconstant as to render an account of them unnecessary.

In the anterior median line, extending from the chin to the symphysis pubis, the transverse position of the points gives the clearest impression on the chin, and next on the upper part of the neck. The points seem to approach one another as they are brought to the bottom of the neck and top of the sternum; the sensibility is increased on the sternum and again diminished at the lower part of the thorax and upper part of the abdomen; a little above the umbilicus it increases again rapidly towards this part; below it, the points appear again to approach one another, and coalesce into one on the symphysis of the pubis.

The application of the two points in a vertical or longitudinal direction on the anterior median line, showed nearly the same alternate increase and decrease of the power of touch.

On the posterior median line, extending from the occiput to the coccyx, the transverse and longitudinal position of the points is most easily recognized near the occiput and between the glutæi muscles. The sense of touch increases to a considerable degree from the sacrum towards the anus; and there is also a place between the scapulæ, on which it is considerably greater than above or below.

In the median lines, therefore, it appears that nearly the same varieties of the sense of touch are perceived by the longitudinal and transverse application of the points; which would seem to show that in these lines of the body the varieties in the sense of touch ought to be attributed not merely to the difference of direction of the course of the nerves, but also to their existing in greater or less quantity, and their being endowed with a more or less acute sensibility.

On the lateral longitudinal lines, extending from the axilla to the crest of the ilcum, the sense of touch seems to be greatest towards the axilla, and towards the crest of the ilcum.

The Causes of this diversity in the sense of touch in different parts of the body, seem on the whole not to be well ascertained. It is sufficiently obvious that the greater sensibility of some parts of the body does not depend on their being more frequently seen than others, as some have supposed to be the case; the middle of the back of the hand, constantly exposed to view, is surpassed by the fingers and palm, and even by the lower end of the fore-arm; the same is the case with the dorsum of the foot. The skin over the os sacrum and coccyx, though beyond the range of vision, is comparatively very sensible. The sensibility of the sub-mental surpasses that of the sternal and ab-

dominal regions; and, though the anterior is generally more sensible than the posterior surface of the body, this would appear to be connected with the structure of the skin rather than with the sight, for the sacrum and coccyx are more sensible than the pubis. Examples of blind persons also, and the great improvement their organs of touch are susceptible of from exercise, sufficiently show that sight has very little to do with our power of distinguishing by touch different regions of the skin. Nor does this power appear to depend chiefly on any mechanical advantage of one part over another, as, for example, that some parts are fixed on bones, and others very moveable. The tip of the tongue and free part of the lips which are loose, and the points of the fingers which are fixed, are possessed of nearly equally acute powers of touch.

The cause of these variations is probably to be sought for in the structure of the skin, with which subject we are as yet, as regards the distribution of the nerves at least, very imperfectly acquainted. It seems to be obvious, however, that the great power of touch does not depend on the presence of papillæ, for the mammaræ and some other parts with numerous papillæ have yet a very blunt sense of touch. The tongue has papillæ over its whole upper surface; but it is only at the tip that the sense of touch is very acute.

Many experiments seem to show that the direction of the course of the larger and smaller nervous twigs has some influence over the power of the skin, by which we distinguish the separate impressions of the points. The greater power which we have of distinguishing the points in a transverse than in a longitudinal position on the arms and legs, while on the face and some parts of the trunk of the body a position of the points parallel to the longitudinal direction of the body gives the clearest double impression, would seem to show that in general the feeling of the distance of the points is most acute, when they are applied across the direction of the nerves in their course. There are, however, other varieties which cannot be so easily explained in this manner, and it becomes necessary to have recourse to the supposition, that the quantity of nervous matter, as well as the mode of its distribution in the skin, may influence to a considerable extent the acuteness of the sense of touch. Sufficient attention has not as yet been given to this part of the subject.

The effect of Motion of our organs, and of the bodies touching them, in augmenting the acuteness of the sensation, is very remarkable. When two points, for example, placed upon the skin appear as one, we can often recognize their double impression by moving the skin. It is thus that by moving the fingers we discover the asperities on surfaces which could not be felt, were the finger held at rest over them. We also acquire a more

accurate knowledge of the nature of an impression, by having it made on different parts of the skin in succession. By a peculiar internal feeling, called the muscular sensation, informing us of the extent of muscular contraction, we come to know the direction and space in which our limbs are moved; and every one knows that this feeling is of very considerable importance in aiding the sense of touch, and in improving that kind of touch frequently distinguished in this country by the term Tact. It has already been remarked, that it is not unfrequently difficult to discriminate whether we judge of the qualities of a surface by the sensibility of the skin, or by the muscular sensation. We can in general tell immediately the direction in which any one pulls the hair of our head; but the knowledge of this direction is not derived, as might be supposed, from the sense of touch, but depends on an exertion of the muscles of the head, which is immediately and insensibly made with the view of resisting the motion of the head, which without it would occur. On fixing the whole head, it will be found that the power of distinguishing the direction still remains, though in a less degree. This seems to depend on the position of the skin in the neighbourhood being altered by traction, for when we fix the skin the power of distinguishing the direction in which the hair is pulled entirely disappears.

Another illustration of this is obtained from the following experiment. Shut the eyes, hold the hand steady, and let some one touch your fingers with, and carry along their points various substances, as paper, glass, metal, wood, quill, leather, linen, silk, or velvet; you will be surprised how often you mistake the one for the other, according as they are more or less lightly pressed against the fingers. Metals when of the same temperature as the hand can scarcely be distinguished from glass and other substances with a smooth surface. When the finger of one person is conducted by another into a fluid, the slight pressure over a considerable surface informs him of its presence. If a person draws a plane surface along the finger of another, pressing at first gently, then gradually more strongly, and again gently, the feeling of a convex surface will be communicated to the finger, and that of a concave surface may be given by the greatest pressure being made at each end.

Professor Weber next relates some experiments which he performed with the view of ascertaining how far we are capable of judging of the Weight of bodies by the sense of touch in the skin, and how far it is necessary that we should be assisted also by the muscular sensation; for it is obvious that in general we make use of both these means to obtain a correct estimate of weight.

He found that when two equal weights * are placed on corresponding parts of the skin, he might add to or subtract from one of them a certain quantity without the person on whose skin they were laid being sensible of any change or inequality in them. He ascertained that when the hand or any other moveable part of the body is laid quite inactive on a table, a much greater change can be made in the relative weight of the two bodies, without its being perceived, than when the limbs are free and capable of muscular exertion: that thirty-two ounces or drachms, for example, may be altered by from eight to twelve, when the hand is motionless and supported, but only by from one and a half to four, when the muscles are in action; and hence Professor Weber infers, that the measure of weight by the touch of the skin alone is more than doubled by the assistance of the muscular sensation.

By these experiments it was found that the lips estimate weight more correctly than any other part of the body: the fingers and toes may be reckoned next, the second phalanx being inferior to the third, and the first to the second: the palm of the hand and sole of the foot, especially the parts covering the ends of the metacarpal and metatarsal bones, possess also a considerable power, while the back, thorax, abdomen, scapulæ, arms, legs and occiput have very little power of estimating weight; which observations obviously show a considerable correspondence between those parts of the skin possessing the most acute sense of touch, and those estimating weights most correctly.

Professor Weber attributes to a more acute sense of touch in the left arm, the circumstance, that to most persons weights appear heavier to the left than to the right arm. This is no doubt to a certain extent caused by the common preponderance of the muscles of the right arm over those of the left; but Professor Weber states that he has also proved that in a large proportion of the individuals on whom he has experimented, the sensibility of the skin on the left arm is greater than that on the right, and he has found, that though the hand is not assisted in any degree by the muscular action or sensation, as when it is steadily supported, weights still appear heavier to the left than to the right arm. Of fourteen individuals of different classes of society, eleven found the weights heaviest in the left hand, two heaviest in the right, and in one there was no difference between the right and left. He also ascertained that this acuteness of touch in recognizing weight, resides not only in the left hand but also in the left foot and scapula.

* The weights employed ought to be made of the same material, and must present the same size and form of surface to the skin. In order to insure this, and to correct the difference of temperature, it is well to interpose similarly shaped pieces of pasteboard between the weights and the skin.

In concluding this account of Professor Weber's researches, which I regret I have been obliged to shorten too much, I may state that I have repeated a considerable number of the experiments on the comparative sensibility of different parts of the skin on my own person, as well as on other individuals, and have obtained very nearly the same results. The acuteness of the sense of touch over the whole skin seems to me to vary more or less in different individuals; but I have not observed any striking deviations from the results recorded in Professor Weber's papers, in respect to the relative acuteness of this sense in the different regions of the body.

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